

# **Patterns of mortality in children presenting to a tertiary paediatric emergency unit in Sub-Saharan Africa: a cross sectional study**



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## **Abstract**

### **Background**

Pneumonia, diarrhoea and perinatal factors are the foremost killers of South African children as in other low- and middle-income countries. Poverty, poor access to care and pre-hospital care are reported major pre-hospital factors and lack of triage, poor skills, delays, poor adherence to treatment protocols and inadequate emergency care determining mortality have been reported to increase in-hospital mortality.

### **Objectives**

To describe the clinical presentation and management of children admitted via the medical emergency unit (MEU) of the Red Cross War Memorial Children's Hospital (RCWMCH) who subsequently died.

### **Methods**

We did a retrospective study undertaking a cross-sectional review of children who died following admission via RCWMCH MEU in 2008. Demographic information, clinical data, time factors and mortality data were reviewed and summarised by descriptive and inferential statistics. The unit utilised the WHO Emergency Triage Assessment and Treatment (ETAT) triage tool, categorising children into Red (emergency), orange (priority) and Green (non-urgent). Patient management was assessed by means of ETAT and the Integrated Management of Childhood Illness (IMCI) tools, which is used to identify severity of illness and strategize treatment plans accordingly.

## Results

A total of 135 children met the inclusion criteria. The crude mortality rate was of 6.25 per 1000 admissions. Of the 135 children who died, 119 (88%) were under five years of age, 33(24%) were HIV-infected, of whom 29 (88%) were under 5 years old. In 67 (50%), a chronic medical condition could be identified while 67 (50 %) were moderately or severely malnourished. There were 29 (22%) deaths within 24 hours of arrival at the MEU. Fifty-five (41%) presented after hours. Community health centres referred 65 (48%) patients, general practitioners referred 20 (15%) and 38 (28%) were self-referred. Ambulance services provided pre-hospital transport to 69 (51%). The two top presenting illnesses in 88 (65%) of the children were acute respiratory illness and acute gastroenteritis. Prior to referral, oxygen was not provided in 57 (59%) children, 35 (71%) with suspected sepsis did not receive antibiotics and glucose was not checked in 39 (80%) with depressed level of consciousness. The median time to ward transfer was 3.23 (IQR: 2.12-4.92) hours. Twelve deaths (9%) occurred in the MEU, 57 (42%) in PICU, 56 (42%) in medical wards and 10 (7%) in specialist wards. The five most common causes of death were acute respiratory infections in 45 (33%), acute gastroenteritis in 27 (20%), septicaemia 22 (16%), meningitis in 13 (10%) and cardiac conditions in 12 (9%) children.

## Conclusion

The top causes of mortality in this hospital cohort in 2008 were pneumonia, acute gastroenteritis, and septicaemia. Using the IMCI and ETAT standard of care, suboptimal management was identified in pre-hospital management, as well as MEU management.

45    Appropriate training and protocol implementation to improve morbidity and mortality should  
46    be undertaken.

47

48    **Keywords**

49    Emergency care, mortality, children, South Africa

(461 words)

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52

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58 To my family and friends, thank you for your support and understanding and never  
59 giving up on me.

60 Above all, to the Creator of all, sincere praise for His grace and mercy.

## **ABBREVIATIONS**

<b>MDGs</b>	<b>:</b>	<b>Millennium Development Goals</b>
<b>UN</b>	<b>:</b>	<b>United Nations</b>
<b>U5MR</b>	<b>:</b>	<b>Under 5 Mortality Rate</b>
<b>HR</b>	<b>:</b>	<b>Hazard ratio</b>
<b>WHO</b>	<b>:</b>	<b>World Health Organization</b>
<b>SDGs</b>	<b>:</b>	<b>Sustainable Development Goals</b>
<b>RCWMCH</b>	<b>:</b>	<b>Red Cross War Memorial Children’s Hospital</b>
<b>ETAT</b>	<b>:</b>	<b>Emergency Triage Assessment and Treatment</b>
<b>ED</b>	<b>:</b>	<b>Emergency Department</b>
<b>MEU</b>	<b>:</b>	<b>Medical Emergency Unit</b>
<b>LMICs</b>	<b>:</b>	<b>Low- and middle-income countries</b>
<b>PMTCT</b>	<b>:</b>	<b>Prevention of mother to child transmission</b>
<b>ChildPIP</b>	<b>:</b>	<b>Child Healthcare Problem Identification Programme</b>
<b>GP</b>	<b>:</b>	<b>General Practitioner</b>
<b>CHC</b>	<b>:</b>	<b>Community Health Centre</b>

<b>IQR</b>	<b>:</b>	<b>Interquartile range</b>
<b>CI</b>	<b>:</b>	<b>Confidence Interval</b>
<b>CFT</b>	<b>:</b>	<b>Capillary Filling Time</b>
<b>IPPV</b>	<b>:</b>	<b>Intermittent Positive Pressure Ventilation</b>
<b>CPAP</b>	<b>:</b>	<b>Continuous Positive Airway Pressure</b>
<b>HREC</b>	<b>:</b>	<b>Human Research Ethics Committee</b>
<b>IO</b>	<b>:</b>	<b>Intraosseous</b>
<b>IV</b>	<b>:</b>	<b>Intravenous</b>

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## Chapter One

### The Research Problem/Introduction

Millennium Development Goal (MDG) 4 entailed reducing under-five mortality by two thirds and this varied based on the country context; in the case of South Africa, this would have required reducing under-five mortality from 60 per 1000 live births in 1996 to 20 per 1000 live births by 2015. [1] This goal was not met. Sustainable Development Goals (SDGs) were then adopted in 2015 at a United Nations congress to address challenges faced globally with regards to poverty, inequality, prosperity, justice and various other challenges. One of the SDGs is to reduce child mortality to less than 25 per 1000 live births by the year 2030. [2]

Prior to the SDGs, the MDGs were devised by the United Nations (UN) in the year 2000. The MDG 4 stated that by the year 2015, global mortality should be reduced by two thirds. [3] There has been a steady decline in the global under-five mortality rate (U5MR) from 93 per 1000 live births in 1990 to 41 per 1000 live births in 2016, equating to a 56% reduction in mortality. [4] However, whilst global mortality has decreased, the World Health Organisation (WHO) reported that Africa still had the highest under-5-mortality rate, 76.5 per 1000 live births, indicating disparities in child survival based on where children live.

Globally, the main killers of children under 5-years-of-age in 2016 were preterm birth complications (18%), pneumonia (16%), intrapartum-related events (12%), diarrhoea (8%), neonatal sepsis (7%) and malaria (5%). [4]



97 Whilst there are published data for causes of childhood mortality such as malaria, acute  
98 respiratory infections and HIV, as well as modifiable factors such as immunisation coverage,  
99 availability of medical services, levels of parental education and residing in a rural area, in  
100 countries such as Malawi and Nigeria [5, 6], there is little known with regards to the factors that  
101 play a role in patients who present to a health facility in South Africa, and any reported  
102 mortality within 24 hours of presentation. Factors such as household poverty, access to care  
103 and emergency medical transport may influence outcome.[6] Children who are critically ill  
104 should be correctly identified by a triage tool at presentation, appropriately resuscitated and  
105 receive effective on-going management in an appropriate ward. [7, 8] Although hospitals with  
106 intensive care facilities may be expected to achieve improved outcomes, poor initial patient  
107 management may still negatively impact on final outcome. The need for triage to prioritise and  
108 categorise acutely ill children arriving at any hospital is highlighted by the fact that many deaths  
109 occur within the first 24 hours of presentation to hospitals in low- and middle-income countries  
110 (LMICs). [9-11] Finally, appropriately skilled staff, as well as evidence-based protocols and  
111 implementation of quality assurance monitoring are factors that may also play a positive role in  
112 any emergency unit managing acutely ill children.[11]

113 The management and outcome of children seen at the Medical Emergency Unit (MEU) of the  
114 Red Cross War Memorial Children's Hospital (RCWMCH) who die within 24 hours is discussed at  
115 the unit's monthly morbidity and mortality meetings. However, a critical review of all the  
116 children dying following admission through the unit has not been formally evaluated and  
117 reported; this review serves to address an aspect of this deficit.

118 The importance of obtaining this information may help identify modifiable factors that could be  
119 reviewed with the view to create prevention strategies and thereby hopefully, reduce  
120 childhood mortality.

## Chapter two

### Literature review

#### Aim of the literature review

This review serves to summarise causes of mortality in children under several headings: global, sub-Saharan Africa (SSA) and South Africa. These headings were chosen because there are differences in child mortality rates depending on where children live. The review will also evaluate the impact of factors that may be associated with mortality in the early phases of management and will also discuss whether any of these causative factors can be prevented and further, identify prevention strategies to improve childhood mortality, as set out in the SDGs.

The mortality of hospitalised children is well described across several settings as greatest within the first 24 hours of presentation, making triage and recognition of serious illness an important intervention point in the child's pathway to care. Malnutrition's contribution to mortality is significant and is often hidden behind the more commonly presented causes of death in most countries, it is thought to be a cross-cutting contributor to mortality in 30-50% of childhood deaths. [12]

HIV remains a huge burden in sub-Saharan Africa and its role in mortality cannot be ignored. In 2015, 36.9% of in-hospital deaths in South Africa were associated with HIV. [12]

## Methodology

A structured literature review was done by accessing the Medline library via PubMed and Google Scholar in November 2018 for publications in English involving children aged 0-18 years, using the following search terms:

- “global” OR “Sub-Saharan Africa” OR “South Africa” AND “child OR childhood” AND “mortality”
- “triage” AND “child” OR “childhood” AND “mortality”
- “child” OR “childhood” AND “HIV” AND “mortality”
- “child” OR “childhood” AND “mortality” AND “malnutrition”

Studies with the following characteristics in their titles were then excluded as they were deemed not relevant to this project:

- Trauma
- Neonatal-specific studies
- Disease-specific studies
- Studies prior to 1998 (>10 years prior to current database)

I then reviewed a total of 283 abstracts which seemed relevant and included the following:

- 88 studies regarding global child mortality
- 75 studies regarding childhood mortality in SSA
- 34 studies regarding childhood mortality in South Africa

- 161 - 32 studies regarding triage and child mortality
- 162 - 30 studies regarding HIV and child mortality
- 163 - 24 studies regarding malnutrition and child mortality

164 However, after a more detailed study of the full text articles and excluding duplicate articles, in  
165 fact only 48 were suitable for inclusion in this literature review because the focus was on the  
166 following selected factors:

- 167 a) Childhood mortality: global
- 168 b) Childhood mortality: sub-Saharan Africa
- 169 c) Childhood mortality: South Africa and access to care
- 170 d) Triage and Emergency management
- 171 e) HIV and Malnutrition

172

## 173 **Results**

### 174 **Global childhood mortality**

175 Global childhood mortality studies have shown a reduction in the under-five mortality rate  
176 (U5MR) from 91 per 1000 live births in 1990 to 43 per 1000 live births in 2015. The United  
177 Nations Inter-Agency Group for child mortality also reported that 16 000 children under the age  
178 of 5 years die daily. [4] While this seems very negative, progress has been made, with 65 out of  
179 195 countries having met the MDG 4 target, thereby saving 48 million lives. Neonatal mortality  
180 rates have been reduced from 36 per 1000 live births in 1990 to 19 per 1000 live births in 2015.  
181 In low- and middle-income countries (LMICs), pneumonia, diarrhoea and perinatal-related

causes remain at the forefront as causes of mortality in children, accounting for 13%, 8% and 7% respectively of the under-5-mortality. In high-income countries, the commonest cause of death is congenital abnormalities. [13, 14]

### **Childhood mortality in sub-Saharan Africa**

More than 50 % (3.3 million) of global child deaths in 2018 occurred in Sub-Saharan Africa (SSA). The overall estimate for SSA as a region is an U5MR of 83/1000 live births. However, mortality rates in SSA vary considerably between countries, with Botswana having an U5MR of 15.6/1000 and Central African Republic having an U5MR of 135/1000 live births. Notably six of the seven countries with an U5MR of more than 100 per 1000 live births are situated in West and Central Africa. They include Somalia, Chad, Central African Republic, Mali, Sierra Leone and Nigeria. [15]

A study regarding access to care showed that only 16 out of 48 Sub-Saharan countries met the international benchmark of more than 80% of the population having access to care within a two-hour travelling distance to a healthcare facility. [16] In Burkina Faso, mortality risk was more than 50% higher if distance to a healthcare facility was more than four hours away. [17] In South Ethiopia, an in-depth look at mortality factors revealed pre-hospital and primary healthcare factors such as poor perinatal care, lack of immunisations, poor vitamin A coverage and not breastfeeding as significantly increasing under-5-mortality. [18] There is evidence showing a strong association between household size and multiple gestations and mortality. [19] There is great disparity between countries across the world and even in SSA. Economic

203 input into improving access to healthcare appears to have played a significant role in reaching  
204 the MDG 4 target. [20]

205 The top three causes of child mortality in SSA are pneumonia, diarrhoea and perinatal-related  
206 factors. In malaria-endemic areas such as Mozambique, Benin, Burkina Faso, Burundi and  
207 Central African Republic, however, malaria is prominent and diarrhoea less common. These  
208 four causes have been unchanged for over 25 years as the top causes of death in SSA, as  
209 evidenced by studies from 1990-2015. [14, 21-23] Factors associated with mortality have been  
210 found to be lack of resources, inadequate senior level of care, access to healthcare and the  
211 effects of poverty such as access to sanitation, as well as lack of maternal education and poor  
212 health-seeking behaviour.[24-27] In a tertiary hospital in Malawi, modifiable risk factors  
213 identified for mortality were appropriate assessment and monitoring and timely provision of  
214 testing and treatment. [9] Staff in resource-constrained areas such as Kenya and Rwanda have  
215 been trained and the staff and triage system evaluated, pre- and post-implementation. [28, 29]  
216 In addition to triage, treatment needs to be implemented timeously, as illustrated in studies  
217 reporting that increased morbidity is directly proportional to increased time to treatment  
218 initiation. [30, 31]

219 In Nigeria, two out of ten children were dying before reaching the age of 5 years in 1990. [32,  
220 33] The under-five mortality rate (U5MR) decreased from 213 per 1000 live births in 1990 to  
221 128 deaths per 1000 in 2013. Infectious diseases accounted for more than 90% of these  
222 deaths. Risk factors related to mortality were access to care and poor recognition of illness, as  
223 well as cultural and resource-related factors.[24] One study showed a 45.9% lower risk of child

mortality in patients with mothers with tertiary education, a 28.3% increase in childhood mortality if living in a rural area and a risk of mortality 49% lower in richer areas, when compared to the poorest areas.[32] Another study from Nigeria showed increased risks for infant and child mortality if a child lived in a low-income household (HR=1.40), multiple gestation (HR=1.94), maternal age <20years (HR=3.04) and lack of maternal education (HR=1.38). [33]

### **Childhood mortality and access to care in South Africa**

In 2005, South Africa was one of only four countries that had shown an increase in U5MR since 1990, the others being Eswatini (formally Swaziland), Lesotho and Zimbabwe. [34] This was largely due to the impact of HIV and HIV-related illnesses. With the introduction of ‘Prevention of Mother to Child Transmission’ (PMTCT) and access to antiretroviral therapy (ART), the U5MR was at 34.7 per 1000 live births in 2015, whereas it peaked at 75 per 1000 live births in 2006. [35] One third of under-five mortality occurs in the newborn period, whilst the most common causes of mortality outside of the neonatal period are similar to those of global trends in low and middle-income countries, with pneumonia, diarrhoea and perinatal-related events cited as the most common causes of death.[36] Pneumonia, diarrhoea and septicaemia accounted for 78% of in-hospital causes of death. Looking at associated risk factors for mortality, 36.9% of in-hospital mortality was associated with HIV disease and 30.9% was associated with severe acute malnutrition (SAM). Further social determinants of health as risk factors include access to water and sanitation. Twenty-six percent of South African children do not have access to clean



running water and 32% do not have adequate sanitation resources.[37, 38] The situation is even more dire in places such as Eastern Cape and Limpopo provinces, where 60% of children have no running water and 49% have no sanitation resources respectively. [12]

In South Africa, strategies have been implemented in order to reduce mortality. Improved services have been provided with regards to primary healthcare with the introduction of the “Integrated Management of Childhood Illnesses” (IMCI) programme, an improved expanded programme on immunization and vitamin A coverage for children under five years of age; all of which played a role in a significant reduction in mortality secondary to diarrhoeal illness. [39] Using these approaches, the diarrhoeal incidence in Limpopo improved from 54 per 1000 to 5 per 1000. The IMCI tool looks at ways to assess and identify illness severity and then classify severity with consequential treatment plans. It was devised by the WHO and UNICEF because most children in the developing world die from illnesses that are preventable. It therefore focuses on treatment entities that are geared at treating pneumonia, diarrhoea, measles, malaria and serious bacterial infection. There is also a national process known as Child Healthcare Problem Identification Programme (ChildPIP) whereby participating hospitals audit all paediatric deaths and modifiable factors identified with a view to preventing future deaths by implementing quality assurance interventions such as community based care, social service interventions, firming up referral pathways and access to care, staff training and allocation, effective triage, protocols, equipment and resource provision at all levels of care. [12]

## **Triage, emergency care and child mortality**

Studies in LMICs reported child mortality within 24 hours of admission to a hospital to be between 34-55%. Early mortality factors have been cited as delayed recognition of illness severity with delayed presentation to emergency centres and delays in emergency centres. Specific clinical signs placing patients at high risk of death within first 24 hours of presentation were fever and subcostal recessions. [40] WHO introduced IMCI and the Emergency Triage and Assessment and Treatment (ETAT) courses to address poor recognition, lack of triage, poor emergency care and poor staff training.[11] In Guatemala, ETAT was shown to lead to a decline in admission rates, as well as a decrease in mortality. [7] Molyneux et al., developed, introduced and highlighted the importance of triage and emergency care in a study performed in Malawi, where appropriate training of staff in ETAT and triage, improving patient flow and good communication with inpatient staff were cited as significant factors that played a role in reducing mortality. With the introduction of triage and improved flow, they reported a massive reduction in number of deaths within 24 hours of admission from 36% to 12.6%. [8] The value of implementing a facility-based appropriate triage system was evaluated in a study performed at RCWMCH, at two different points in time, with the outcome showing an appropriate threefold increase in admissions for each advance in triage colour, as well as a strong association between triage colour and severity of illness, indicating appropriate prioritisation of care. In addition, more than 90% of patients were appropriately triaged with the use of the Emergency Triage Assessment and Treatment (ETAT). [11]

## **Role of HIV in child mortality**

In South Africa, between 2006 and 2011, child mortality was associated with HIV in 43% of cases. With subsequent efficient rollout of PMTCT and ART, a decline was noted down to 36.9% by 2015. The risk of dying secondary to an HIV-related illness was also noted to be higher if the maternal viral load was high and in patients from a lower wealth index.[41] Subsequent to the introduction of PMTCT and ART, there was a significant reduction in South Africa's overall mortality. [42, 43]

## **The role of malnutrition in child mortality**

Sub-Saharan Africa has high rates of malnutrition, with East and West Africa being the worst affected.[44] Malnourished children are at high risk of mortality, secondary to metabolic instability and immune compromise, which in turn results in susceptibility to infection, placing them at greater risk and converting simple gastroenteritis and pneumonia to lethal events.[45] According to the United Nations Children's Fund and WHO, children with severe wasting have a nine-fold risk of death compared to normally nourished children. [45]A study in Eswatini (Swaziland) showed that weight-for-height and associated oedema increased the risk of mortality.[46] A West African mortality study looking at factors contributing to death within 24 hours of presentation, revealed malnutrition as one of these contributory factors.[10] Another study in Malawi reported that an analysis of the reduction in their U5MR from 247 per 1000 in 1990 to 71 per 1000 in 2013, was partly attributable to a reduction in malnutrition.[47]

## Discussion

There has been a decline in global child mortality. The decline, however, has not been adequate to meet the MDG4 of 2000. The SDG 3 target for 2030, which was subsequently set in light of the MDG 4 target not being met, is attainable, but will require some developing countries to implement strategies such as improved access to care, as well as political and economic input.

This will be in keeping with the WHO Universal Health Coverage Strategy of achieving universal health coverage, financial risk protection, access to quality essential health-care services and access to safe, effective, quality and affordable essential medicines and vaccines for all.

Pneumonia and diarrhoea as persistent significant causes of mortality prompts improved access to care, maternal education and appropriate resources within appropriate travelling distance.

In terms of perinatal-related events, lack of antenatal care has been identified as a very important risk factor for neonatal mortality.

In SSA, malaria is endemic and in many SSA countries, it is the most common cause of childhood mortality. HIV exposure or disease as well as malnutrition are very often comorbid factors that contribute to high mortality in this region. There have been numerous studies evaluating risk factors for mortality. Much emphasis has been placed on improvement of primary healthcare and access to care facilities. These two factors appear to play a role with regards to morbidity and mortality across SSA, with economic input required in order to create appropriate health services, as well as appropriate and attainable transport or access to care, whether it be mobile health care services or improved infrastructure and transportation. The poorer countries have an additional burden of poor maternal education, increased parity and poor immunization coverage. There is a need to improve access to education and in addition,

328 strategies need to be put in place that empower parents to recognize ill health and act  
329 appropriately. Immunisation campaigns have been implemented, but it is uncertain why the  
330 access to immunisations has been blunted in certain areas such as Rwanda. Prenatal care is a  
331 great concern as well as antenatal care, as these are entities that not only impact mortality, but  
332 also the general health and well-being of the newborn and the mother. In addition, there  
333 appears to be a strong association between household size and multiple gestations and  
334 mortality. Again, it appears that economic input, as well as access to care are shortfalls which  
335 will continue to impact mortality, should there not be a change.

336 However, it is with great dismay that 6 of the SSA countries still have 1 out of 10 children dying  
337 before they reach the age of 5 years. What is poorly understood is how these countries differ  
338 from those who have met the MDG 4 target. Factors such as war, unrest and a poor resource  
339 provision may play significant roles. However, evidence does not reveal absolute risk factors  
340 and the magnitude thereof in the Central African countries. Malawi, Kenya and Nigeria are  
341 relatively well studied populations in terms of childhood mortality and have shown major  
342 advances in improved mortality.

343 In South Africa, the U5MR has steadily declined since 2006, but not rapidly enough to reach the  
344 MDG 4 target. In 2015, U5MR was at 34.7 per 1000 live births with the most common causes of  
345 death, according to the Child Problem Identification programme (Child PIP), being infectious  
346 causes. Pneumonia, diarrhoea and septicaemia remain at the forefront as the most common in-  
347 hospital causes of death. Factors such as HIV disease and severe acute malnutrition (SAM)  
348 continue to impact and increase risk of mortality, as well as social determinants. Access to clean

349 running water and adequate sanitation resources are major risk factors that require economic  
350 input and government intervention.

351 With regards to factors leading to mortality and a more in depth look at triage and the first 24  
352 hours of admission, studies revealed that appropriate triage aids in recognition and appropriate  
353 timing in management, thereby affecting morbidity and mortality. Triage systems should be  
354 geared at what is applicable to a setting and should aid in risk identification and stratification.

355

## 356 **Conclusion**

357 This literature review highlights that pneumonia, diarrhoea and perinatal factors are the  
358 foremost killers of SA children, these factors are similar to those found in other low-and middle-  
359 income countries. There is an urgent need to evaluate strategies to prevent these diseases from  
360 causing mortality. There is enough evidence to advise policy on mandatory triage, resuscitation  
361 and appropriate on-going care.

362 This review is followed by a study that looked at the cause of deaths of children admitted via  
363 the medical emergency unit of a children's hospital over one year and aims to evaluate the  
364 presenting illness and triage characteristics, and impact of treatment and other factors on their  
365 mortality.

366

## Chapter three

### Aims and Objectives

#### 3.1 Aims

To describe the clinical presentation and acute management of children admitted via the medical emergency unit (MEU) at the Red Cross War Memorial Children's Hospital (RCWMCH) who subsequently died.

#### 3.2 Objectives

- To describe the crude mortality rate (per 1000 admissions) for children admitted to the hospital via the MEU
- To describe the demographic characteristics, clinical presentation, and management of the children that die following admission via MEU
- To describe the causes of death of children admitted via the MEU of the RCWMCH

## Chapter four

### **Methodology**

#### **Setting**

The study was done at Red Cross War Memorial Children's Hospital (RCWMCH) - a tertiary academic hospital in the Western Cape Province, South Africa. RCWMCH provides secondary and tertiary level care to approximately 1.4 million children aged 0-14 years from all over the Western Cape, as well as quaternary care to patients from across the country.

Approximately 35 000 children present to the emergency unit at RCWMCH per annum.

With regards to the Sustainable Development Goals, it was necessary to ascertain all factors that could effectively assist in achieving these goals. Therefore, this study undertook to describe demographics, potential risk and modifiable factors of patients who presented to the RCWMCH medical emergency unit in one year, 2008, and died at or during the admission.

#### **Study design**

A descriptive retrospective cross-sectional study with an analytical component

#### **Study Population**

All children who presented to RCWMCH in 2008, who subsequently died in hospital.

#### **Inclusion criteria:**

Children admitted via the medical emergency service at RCWMCH and subsequently died in hospital within the study period 2008.



## **Exclusion criteria**

Children admitted directly to any wards of RCWMCH from any other source than the medical emergency unit.

## **Definitions**

For the purposes of this document the following definitions were used:

- Emergency Treatment Assessment and Treatment (ETAT) is a WHO tool that trains and equips frontline staff at health facilities with the skills to recognise and identify critically ill children and then to systematically manage them according to Advanced Paediatric Life Support principles of airway, breathing, circulation, coma and dehydrating diarrhoea with assessment and management. The first step in identifying critically ill children is by triage into one of three categories: Red category- children with emergency signs requiring immediate treatment; Orange category- those with priority or urgent signs and requiring urgent care and Green category- those children with non-urgent conditions who can await care in a queue. [11]
- HIV infection: “a positive HIV DNA PCR result confirmed by either a HIV RNA PCR or repeat HIV DNA PCR test, in any child < 18 months old, or 2 positive serological test results (HIV ELISA or HIV Rapitest) or a positive HIV DNA PCR result confirmed by either a HIV RNA PCR or repeat HIV DNA PCR test, in a child > 18 months old were considered HIV-infected” [48]
- Unknown HIV status: any infant or child where there was no record of HIV testing at the National Health Laboratory Services (NHLS) laboratory database and whose mother’s HIV status was unknown.

- 425 • HIV-exposed status: Any infant or child whose mother's HIV status was known to be positive  
426 during pregnancy and whose own status was negative by HIV testing at the NHLS laboratory.  
427 Using World Health Organisation (WHO) growth reference standards, moderate underweight  
428 was classified as weight-for-age z score (WAZ) between -2 and -3 standard deviations (SD)  
429 below the median while severe underweight was a WAZ < -3 SD. [45]
- 430 • Impaired Circulation: capillary filling time more than 3 seconds or weak pulse or cold  
431 extremities [11]
- 432 • Severe dehydration: two or more signs of lethargy, sunken eyes and very slow skin pinch  
433 [11]
- 434 • Shock: all of -capillary filling time more than 2 seconds and weak and/or fast pulse and cold  
435 hands[11]
- 436 • Hypoxaemia: pulse oximetry saturation less than 90% [11]
- 437 • Hypoglycaemia: point-of care glucose measurement less than 3mmol/L [11]

438

439 **Data collection:**

440 This was a data analysis performed on a database compiled in 2008 at the MEU at the  
441 RCWMCH. The data was collected by performing a retrospective folder review of all deaths that  
442 occurred in patients who presented to RCWMCH MEU where a meticulous register is kept of all  
443 children passing through- arrival and disposition. The case notes were retrieved from the  
444 medical records department and data abstracted. There were no missing folders and the  
445 resuscitation sheet is standardised for all children, however, there may have been some

variation in the detail recorded within the folders. Incomplete data were recorded as such in the results.” The variables collected included:

*1. Demographic data:*

- a. Age, sex, weight, weight-for-age z-score, HIV status

*2. Clinical data:*

- a. Clinical presentation, triage information, clinical diagnosis, pre-hospital and in hospital treatment.

*3. Time factors:*

- a. Time of admission, time to initiation of treatment, time to ward transfer.

*4. Mortality data:*

- a. Cause(s) of death, time to death, and place of death

**Data Analysis:**

The analysis was done using STATA Statistical software, release 13, (College Station, Texas, USA) and constituted descriptive and analytical components.

*Numerical data*

Numerical data was tested for normality. Data was summarised using mean(s) with standard deviation(s) or median(s) with interquartile range(s) as appropriate. Hypothesis testing was done with a t-test on data with normal distribution, and Wilcoxon Ranksum used to test non-parametric distribution. A level of two-sided  $p < 0.05$  was chosen for statistical significance.

*Categorical data*

467 Categorical data were presented as proportions together with the 95% confidence interval. The  
468 chi-squared test was performed between categorical data to look for association. A significance  
469 level of  $p < 0.05$  was chosen.

470

471 **Ethical considerations:**

472 The study was submitted for ethical review to the Human Research Ethics Committee (**HREC**  
473 **Ref: 747/2018**) of the Faculty of Health Sciences at the University of Cape Town and had the  
474 approval of the RCWMCH Administration. In view of the retrospective nature of the study, the  
475 Ethics committee was approached to provide a waiver of individual consent. The study was  
476 done in accordance with the Declaration of Helsinki, 2013.

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## Chapter five

### 479 Results

#### 480 Mortality and demographics

481 A total of 135 patients died following treatment in the medical emergency unit (MEU) at the  
482 Red Cross War Memorial Children's Hospital (RCWMCH) from January to December 2008. Over  
483 this period 21 600 children were admitted to RCWMCH, giving a crude mortality rate of 6.25  
484 per 1000 admissions for the year. The median age of the children who died was 8 months with  
485 an interquartile range (IQR) of 3 to 17 months; 81 (60%) were infants of whom 40 (30%) were  
486 under 3 months, 38 (28%) were aged 12-59 months, and 16 (12%) were more than 5 years-old.  
487 There were 67(50%) male children. **(Table 1)**

488 The median weight-for-age z-score was -2 (IQR -3.2 to -1). There were 67(50%) with moderate  
489 or severe underweight-for-age children, 28 of whom were moderately underweight-for-age  
490 (UWFA) and 39 who were severely underweight-for-age.

491 Of 108 children with known HIV status, 33 (31%) were HIV-infected, 66 (61%) unexposed  
492 uninfected, and 9 (9%) were HIV-exposed uninfected. The HIV status was unknown in 27 (20%).

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**Table 1: Demographic Characteristics of the study children (n=135)**

	Number	Percentage
<b>Age in months</b>		
<1 month	20	15
1 to 3 months	20	15
3 to 11 months	41	30
12 to 59 months	38	28
>60 months	16	12
<b>Sex</b>		
Male	67	50
Female	68	50
<b>Weight-for-age<sup>#</sup></b>		
Normal WFA	66	50
Moderate UWFA	26	20
Severe UWFA	41	30
<b>HIV status</b>		
Unexposed uninfected	66	49
Infected	33	24
Exposed uninfected	9	7
Unknown	27	20
<b>Referral status</b>		
<b>Unreferred</b>	38	28
<b>Referred</b>	97	72
Community Health Centre	65	48
General Practitioner	20	15
Other hospital	12	9
<b>Telephonic notification</b>		
No	105	78
Yes	30	22
<b>Mode of Transport</b>		
Ambulance	69	51
Own Transport	62	46
Unknown	4	3

WFA: weight-for-age; UWFA: underweight-for-age; <sup>#</sup>moderate underweight = WFA z-score between -2 and -3 and severe underweight WAZ < -3 SD

## **Referral pattern**

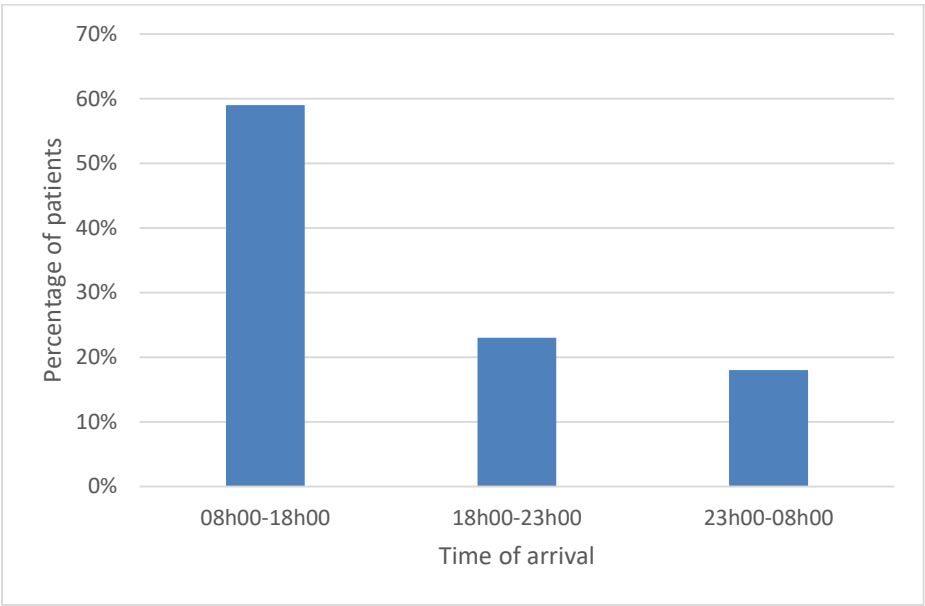
The children lived in six main health sub-districts within the Western Cape Metropolitan area: most of the patients that died came from Khayelitsha (n=44; 33%) and the Klipfontein sub-district (n=40; 30%). There were 29 (22%) children from Mitchells Plain, 8 (6%) from the Southern, 7 (5%) from the Tygerberg and 6 (4%) from the Western health districts. There were 69 (51%) children brought by the emergency ambulance services and 62 (46%) arrived by private transport. The mode of arrival was unknown for the remaining four children.

Telephonic notification of referrals to the MEU was made in 30 (22%) cases. General practitioners (GP) referred 20 (15%), the community health centres (CHC) referred 65 (49%), and 12 (9%) came from other local hospitals, whilst 38 (28%) of children were self-referred.

## **Time of arrival at RCWMCH emergency and triage**

Eighty (60%) patients arrived during normal working hours between 08h:00 and 18h:00, while 55 (40%) arrived between 6pm and 8am, **Figure 1**. At triage, 98 (73%) were categorised as red (emergency) and 31 (23%) as orange (priority). One patient was triaged as green (non-urgent) category. Five patients did not have a triage category assigned.

**Figure 1: Time of arrival of 135 study children in the medical emergency unit**



**Clinical presentation at MEU and triage information**

**Presenting diagnosis**

The top three presenting diagnoses were pneumonia, acute gastroenteritis and septicaemia. (Table 2); 113 (84%) children had more than one clinical diagnosis at presentation.



528 **Table 2: The presenting condition of the 135 study patients**

PRESENTING ILLNESS	N	(%)
Pneumonia	62	46
Acute gastroenteritis	35	26
Septicaemia	33	24
Cardiac	23	17
Acute neurological	20	15
Severe acute malnutrition	16	12
Other	16	12
Bacterial meningitis	8	6
Tuberculous meningitis	7	5
Pulmonary tuberculosis	6	4
Acute surgical abdomen	6	4

529

530 Hypoxaemia as indicated by pulse oximetry <90% was a feature at presentation for 81 (60%)

531 children. There were 61 (45%) children identified with impaired circulation and 43 (32%) with

532 shock having a capillary filling time (CFT) of more than 2 seconds plus a weak pulse and cold

533 extremities. Diarrhoea with dehydration was present in 48 (36%) children with signs of severe

534 dehydration in 23 (48%) of those children.

535 Sixty-seven (50%) children had a chronic underlying medical condition and there were five

536 children who had more than one underlying medical condition. **(Table 3)**

537 **Table 3: Underlying medical conditions of study population, n=135**

Underlying Diagnosis	n (%)
None	68(50)
HIV	33(24)
Cardiac	13(10)
Cerebral Palsy	5(4)
Down Syndrome	5(4)
Chronic Lung Disease	2(2)
Tuberculous Meningitis	2(2)
Inborn errors of metabolism	1(1)
Neoplasm	1(1)
Chronic Renal Disease	1(1)
Unspecified syndrome	1(1)
Asthma	1(1)
Neurofibromatosis	1(1)
Sickle cell anaemia	1(1)

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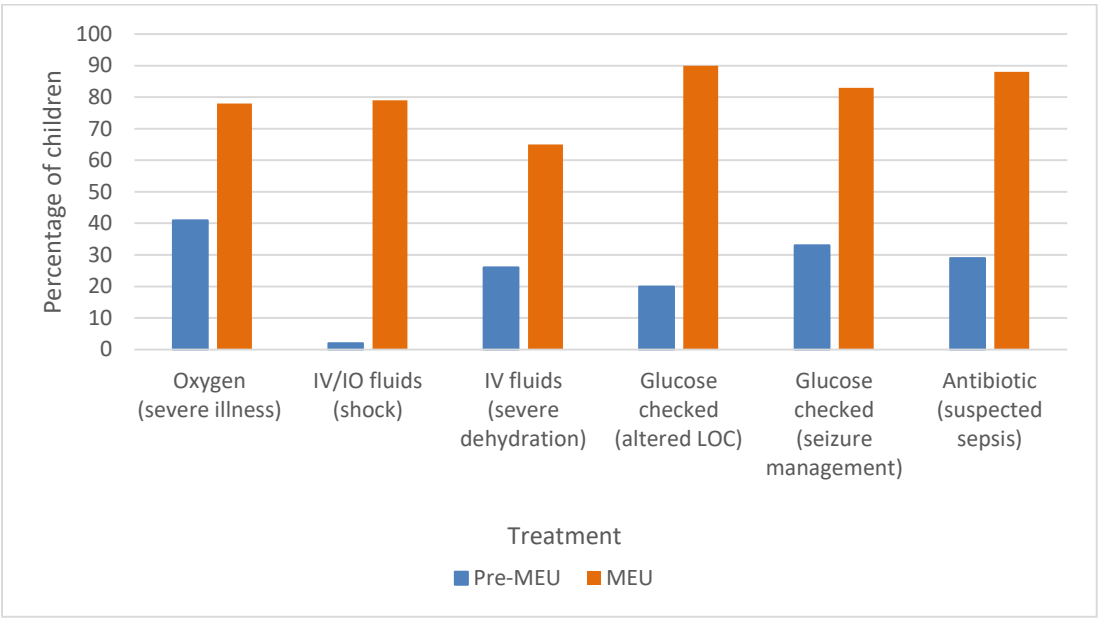
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**Figure 2: Treatment at referral centres and MEU**



Legend: MEU – medical emergency unit; IV – intravenous; IO – intraosseous; LOC – level of consciousness

**Treatment at referral centres and MEU**

The management of the severe illness was evaluated according to the treatments in parentheses **Fig 2:**

- A. Hypoxia (oxygen given)
- B. Shock (intravenous/intraosseous fluid bolus)
- C. Diarrhoea with severe dehydration (intravenous fluids)
- D. Seizures (glucose check)
- E. Altered level of consciousness (glucose check)
- F. Suspected sepsis (antibiotics given)

**A. Management of severe illness with oxygen**

Pre-hospital oxygen was given in 40 (41%) of the 97 children who were referred. One hundred and five (78%) received oxygen in the MEU. Eighty-one (60%) of the children had documented hypoxia.

**B. Shock management**

There were 43 (32%) children who had shock documented. Of these, eight (2%) received a fluid bolus at the referral centre, whilst 34 (79%) received a fluid bolus in the MEU. One child's records did not document whether a fluid bolus was given.

**C. Diarrhoea with severe dehydration management**

There were 23 (17%) children with diarrhoea with severe dehydration; an intravenous (IV) line for IV rehydration fluids was inserted at the referral centre in 6 (26%) of these children, whilst IV fluids were commenced in 15 (65%) of the children who presented with severe dehydration in the MEU.

**D. Management of altered level of consciousness**

Of the 49 (36%) children who had an altered level of consciousness, a glucose check was done in 10 (20%) children at the referral centre. At the MEU 44 (90%) children had a glucose check.

#### **E. Management of seizures**

Fifteen children were referred with seizures from the referral centre. Of these children, a glucose check was not done in 10 (67%).

Eighteen children were diagnosed with seizures at the MEU. Fifteen (83%) had a glucose checked.

#### **F. Management of suspected sepsis**

There were 49/135 (36%) children who presented to the MEU with suspected sepsis, with either hypothermia or pyrexia, of whom 14 /49 (29%) received antibiotics at the referral centres, with antibiotics documented as given in 43/49 (88%) children in the MEU.

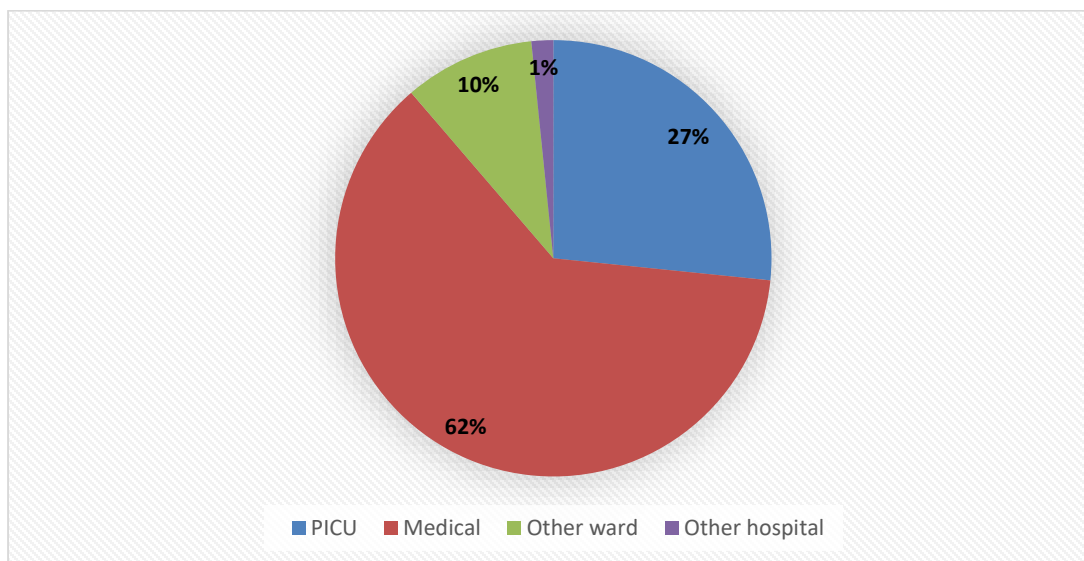
### **Outcomes**

#### **Ward transfer**

Of the 125 patients who were transferred from the MEU to wards, 33 (26%) were admitted to the Paediatric Intensive Care Unit (PICU) from the MEU, 77 (62%) to the medical wards, 12 (10%) went to a specialized medical or surgical ward and 2 (2%) were transferred to secondary level hospitals. **Figure 3**

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**Figure 3: Destination ward after stabilisation in the MEU**



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Legend: MEU: medical emergency unit; PICU: paediatric intensive care unit

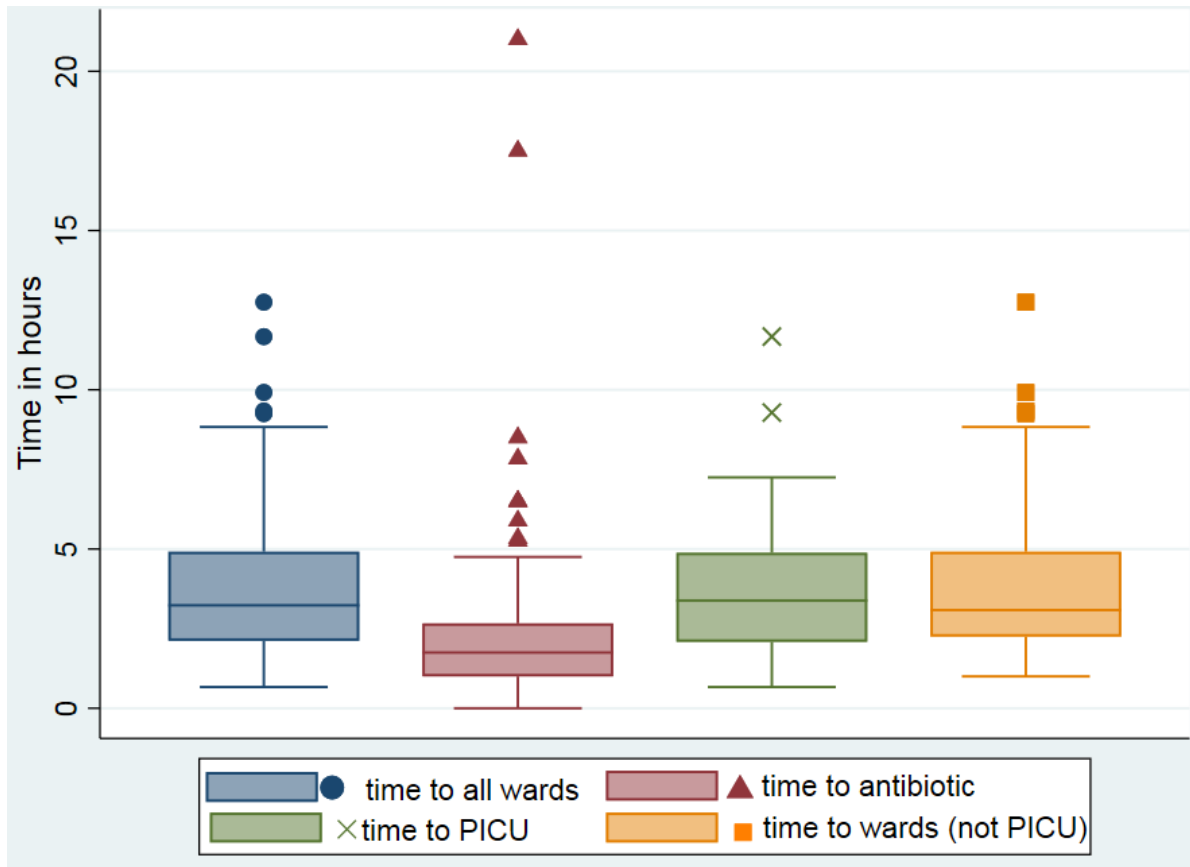
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### 602 Time Factors

603 Once stabilisation had occurred, six of the 125 (5%) patients who were transferred from the  
604 MEU to other wards, were transferred within an hour. The other 119 (95%) were transferred at  
605 later than one hour to an inpatient ward. There was no significant difference in the median  
606 time to ward transfer was 3.23 (IQR 2.1-4.9) hours compared to the median time to PICU  
607 directly from the MEU, was 3 (IQR 2.0-4.0) hours. Of the 33 children transferred to ICU 8 (24%)  
608 were transferred within an hour.

609 Of the 102 (76%) who did not receive antibiotic prior to MEU, 21 did not have records of having  
610 received antibiotic before death. Of the remaining 81 (79%), time taken to the first dose of  
611 antibiotic being administered to patients was a median of 1.75 hours (IQR 1-2.6).

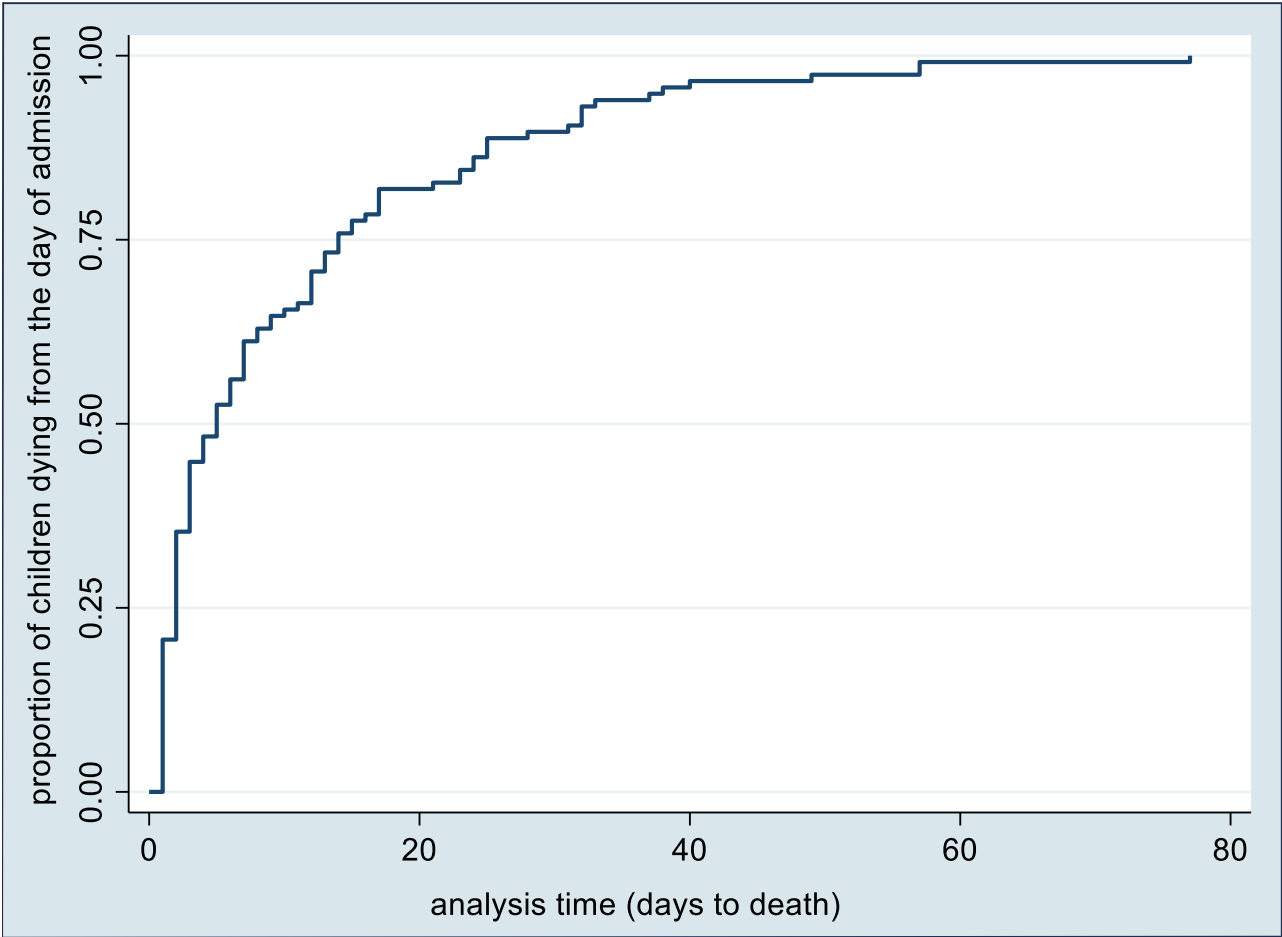
**Figure 4: Box and whisker plot of time variables**



Legend: PICU – Paediatric Intensive Care Unit; (for completeness and accuracy, outliers are indicated for each plot by circles, triangles, crosses and squares)

A survival curve showing time to death is shown in **Figure 5**. There were 29 (22%) children who died within 24 hours of presentation. Forty-five percent of children died within 72 hours of admission; 80% died within 17 days of admission and 20% died between day 18 and day 80.

*Figure 5: Graph showing the cumulative mortality over time of the study children from the time of admission to the medical emergency unit (MEU)*



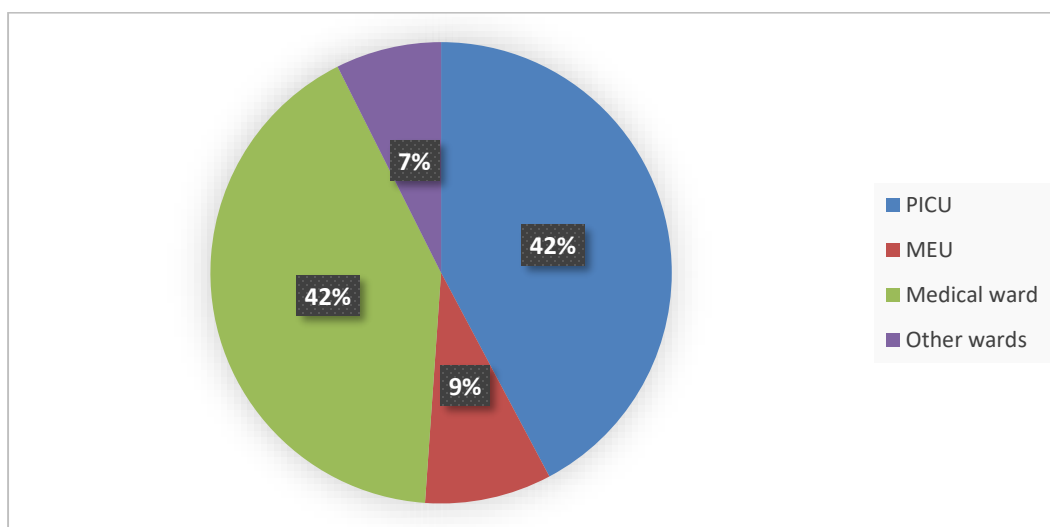
### Place of death

Of the 135 deaths, there were 12 (9%) that occurred in the MEU, 56 (42%) occurred in the PICU, 56 (42%) in the medical wards and the last 10 (7%) in the speciality wards. (**Figure 6**)



630

*Figure 6: Place of death of study patients*



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Legend: PICU: paediatric intensive care unit; MEU: medical emergency unit

### 633 **Deaths within the first 24 hours**

634 There were 29 (22%) children who died within 24 hours of presentation. Twelve (41%) of these

635 29 children died in the MEU, 11 (38%) died in PICU and 6 (21%) died in the medical wards.

636 Three of the 29 (10%) were HIV-infected, none of whom went to the PICU.

637 Causes of death in this group of children were acute gastroenteritis 12 (41%), acute respiratory

638 infection 6 (21%), septicaemia 6 (21%) and cardiac pathology in 5 (17%) as a primary cause of

639 death in the form of cardiomyopathy, myocarditis or congenital cardiac disease. (**Figure 7**)

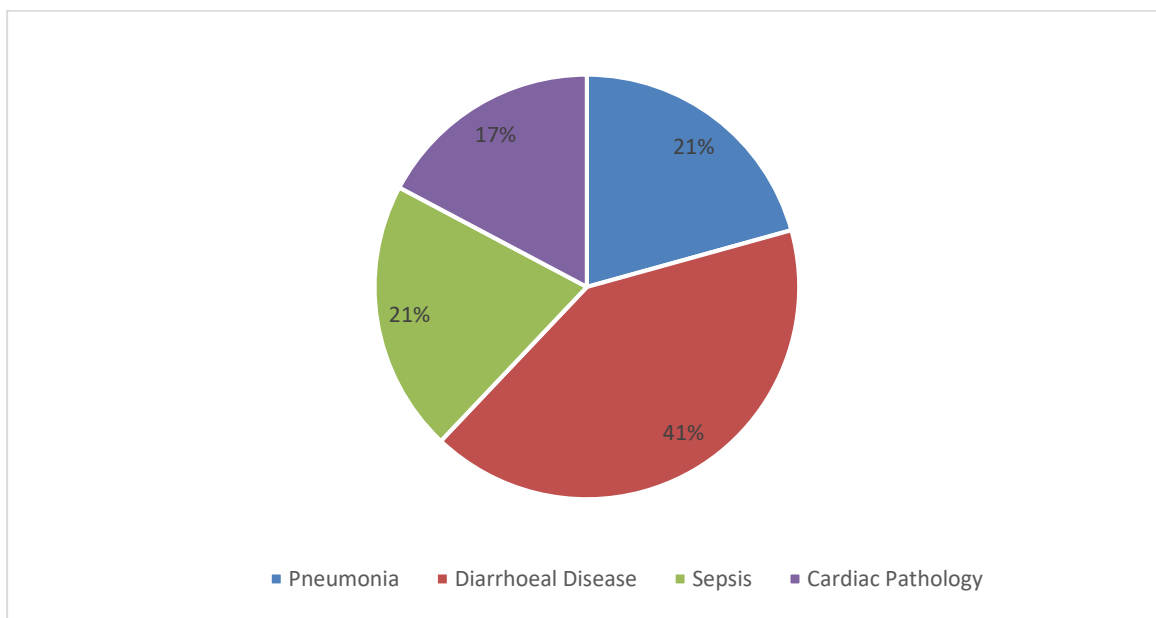
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**Figure 7: Causes of death of patients who died within 24 hours (n=29)**



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#### 646 **Cause of death**

647 The top five primary causes of death were acute respiratory infections (ARI) 45 (33%), acute  
 648 gastroenteritis (AGE) 27 (20%), septicaemia 22 (16%), meningitis 12 (9%) and mixed cardiac  
 649 disease 12 (9%). There were 82 (61%) patients with secondary diagnoses and 21 (16%) with a  
 650 third diagnosis or underlying condition. A further 3 (2%) had a fourth diagnosis or underlying  
 651 condition. **(Table 4)**

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653

654 **Table 4: The primary cause of death in the study children (n=135)**

Primary cause of death	N	%
<b>Acute respiratory infection</b>	45	33
<b>Hypovolaemic shock secondary to AGE</b>	27	20
<b>Septicaemia</b>	22	16
<b>Bacterial meningitis</b>	8	6
<b>Tuberculous meningitis</b>	5	4
<b>Surgical (Acute abdomen)</b>	5	4
<b>Cardiomyopathy</b>	4	3
<b>Complex congenital cardiac</b>	4	3
<b>Myocarditis</b>	4	3
<b>Liver failure</b>	3	2
<b>Status epilepticus</b>	1	1
<b>Suffocation</b>	1	1
<b>Diphtheria</b>	1	1
<b>Malignancy</b>	1	1
<b>Inborn error of metabolism</b>	1	1
<b>Severe anaemia with congestive cardiac failure</b>	1	1
<b>End stage renal failure (Nephrotic Syndrome)</b>	1	1
<b>Cerebral haemorrhage</b>	1	1

655 Legend: AGE- acute gastroenteritis; percentages rounded to whole numbers

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657

658     **The role of HIV infection**

659     Of the 33 HIV-infected children, 19 (58%) were under 1 year. There were 18 (55%) female  
660     children. It is unknown whether patients were on antiretroviral therapy and their viral loads  
661     and CD4 counts were not recorded. Of those who were HIV-infected, 3 (9%) were admitted to  
662     ICU. Eighteen (27%) of the 66 patients who were HIV-uninfected went to ICU.

663     The most common causes of death in the HIV-infected group of children were ARI 18 (55%),  
664     AGE 8 (24%) and septicaemia 4 (12%).

665

666     **The role of malnutrition:**

667     In the study population, there were 67 (50%) children who were moderately or severely  
668     underweight-for-age, ten (15%) of these children died within 24 hours. Seventeen (25%) were  
669     HIV-infected. The top three causes of death in this group was 25 (37%) with acute respiratory  
670     infections, 14 (21%) with acute gastroenteritis with hypovolaemic shock and 13 (19%) with  
671     septicaemia.

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## Chapter six

### Discussion

In our study, we described the demographics of 135 children who presented to the MEU at Red Cross War Memorial Children's Hospital in the year 2008, who subsequently demised. The leading causes of death were acute respiratory infections, diarrhoeal disease and septicaemia, in keeping with mortality studies from other developing countries including Angola, Nigeria, and Malawi, as well as in South Africa. [36, 49, 50]

Most of the children attending the MEU (73%) were critically ill and appropriately identified at triage as "Red" category cases. There was only one patient who subsequently demised and was triaged "Green", this is likely an error in triage assessment. Sixty percent of patients who died were under 1 year of age. This correlates with global statistics where childhood mortality studies have shown that up to two thirds of childhood deaths occur in infancy.[49, 51] The burden of critically ill children remains high in SSA, mortality in the first twenty-four hours was 22% (29/135) in the present study; in one study Malawi reported a rate of 44%.[5] Nigeria, a rate of 57%.[6] What is evident is that 11 years after this study, acute respiratory infections, diarrhoeal disease and sepsis remain the top causes of mortality in sub-Saharan Africa and provides a strong focus for preventive strategies. [12]

One of the factors being addressed is malnutrition, which is thought to contribute to half of the global under-5-years mortality and is thought to be related to decreased immunity and causal increased severity of illness.[45] Similarly, in this study, 50% of patients were moderately to severely underweight-for-age.

695 HIV disease as well as HIV exposure continues to play a role in mortality, but this has improved  
696 substantially since the rollout of the prevention -of-mother-to-child-transmission (PMTCT)  
697 programme, with a reduction in HIV-related under 5 mortality having declined from 116.8  
698 deaths per 100 000 population in the period 2001 to 2004 to 14.8 deaths per 100 000  
699 population in the period 2010 to 2014.[52] In our study 24% of children were HIV-infected.  
700 Disparity still exists but has shown improvement in certain sub-districts such as Khayelitsha,  
701 where HIV-related deaths declined from 230.5/100 000 to 21.1/100 000 in the same  
702 aforementioned periods.[52]

703 Patients were referred from various centres. Community health centres provided treatment to  
704 most of the referred patients. Despite treatment provided, a significant number of patients did  
705 not receive IMCI-defined adequate treatment modalities, as can be noted with regards to  
706 oxygen provision for hypoxia, glucose checks, fluid management and antibiotic provision. This  
707 has been shown to be of concern in various sub-Saharan countries.[53] The patients who were  
708 referred by GPs had received no treatment prior to presentation. This raised the concern with  
709 regards to adequate and appropriate care provision in primary health. The Advanced Paediatric  
710 Life Support course emphasises stabilisation of airway, breathing, circulation and dextrose prior  
711 to transfer. This study marks a need to provide more support to primary health care, with  
712 subsequent development of district paediatric care and outreach.

713 A significant number of patients who presented, resided in Khayelitsha, a township in the  
714 Metro East of the Western Cape, where many children reside in informal dwellings, have  
715 limited access to tap water within their dwellings and generally poor sanitation services. There

were also a large number of patients who presented from the Klipfontein sub-district, a middle- to low-income area situated within a 5km radius from Red Cross Children's Hospital. These two areas accounted for more than 60% of the study population who presented. It was therefore pertinent to address the two areas as to how socioeconomics impacts on health and the challenges experienced. Red Cross War Memorial Children's Hospital is situated more than 20km away from Khayelitsha, thereby impacting further on access to care. Khayelitsha is the second largest township in South Africa. In 2008, 15% of the MEU attendees were from Khayelitsha of whom 33% died. Access to emergency care is restricted due to lack of transportation, inability of emergency services to access certain areas within the township and continued informal dwellings being erected without appropriate infrastructure. These poverty challenges may continue to maintain differential mortality statistics. Access to healthcare has been partially addressed by the opening of a district hospital in Khayelitsha in 2012. This has aided in the decline in under-five mortality of 976.6 deaths per 100 000 population in the period 2001 to 2004 to 570.2 deaths per 100 000 population in the period 2010 to 2013, a decline of 41.6%.[52] Despite the significant improvement in mortality, Khayelitsha still remains the sub-district with the highest U5MR.

With 73% of the study population being triaged as 'Red' category, time of presentation is another important consideration as a risk factor for mortality, as the staff complement is diminished in both number and expertise after 5pm in the evening.[54] This places critically ill children at risk for possible management errors.

736 Delayed antibiotic administration in children with severe sepsis has been shown to be a risk  
737 factor for increased mortality.[54, 55] In 2008, within the MEU, there was a significant time  
738 delay in time to antibiotics, with less than 25% of patients receiving antibiotics within the  
739 recommended “golden hour”. The reason for this is unclear. Access to the ICU or wards was  
740 also significantly delayed, with less than 25% of patients being transferred from the MEU within  
741 2 hours of arrival and a further 25% only exiting the MEU more than 5 hours after arrival. This  
742 has resulted in a need for upskilling of ward staff, provision of more high care beds and very  
743 recently, the upgrading and resultant increased capacity of the ICU. It would be valuable to  
744 review time delays to transfer now that capacity has been increased, along with looking at  
745 factors causing any delays.

746 Over 80% of the study patients had more than one recognised diagnosis as a possible cause of  
747 death indicating the complexity of pathology which may be related to the study site being a  
748 tertiary referral centre.

749 Programmatic improvements in many South African child health issues since 2008 may well  
750 have affected the disease spectrum and severity in the communities covered by Red Cross War  
751 Memorial Children’s Hospital e.g., improved prevention -of-mother-to-child-transmission  
752 (PMTCT) of HIV disease, encouraged breast-feeding including in the context of HIV, access to  
753 antiretroviral therapy to mothers and children, strengthening of primary health care and pre-  
754 hospital emergency medical services, the introduction of mandatory triage and life support  
755 training for all staff seeing children. The first 1000 days initiative, which prioritises the care of  
756 an infant from conception to the age of 2 years under the 3 domains, grow, play and love, aims



to improve the nutrition, health, development and social well-being of all children and thereby, optimise health, growth, brain development and social skills, so as to improve their future and the future of society. This initiative has been recognised by the Western Cape department of health (WCDOH) as an initiative that will be implemented throughout facilities and practices that involve the care of mother and child antenatally as well as postnatally.

### **Limitations**

This study was a retrospective study conducted at a single centre in 2008 and had inherent limitations of incompleteness of information and missing data contained in handwritten patient records and referral letters. It is also possible that the urgency involved with stabilising and transferring a critically ill child in a busy unit, both pre-hospital and at the MEU, may be associated with incomplete documentation of all treatments and interventions given. The protocols available in 2008 were no longer available to scrutinize either at the pre-hospital or emergency room level. Since then, new protocols including the Child PIP death review process and staff training programmes have been implemented to improve management outcomes. Nevertheless, notwithstanding all limitations, this audit is an important clinical governance tool that necessitated completion.

It is important for emergency units to conduct audits of this nature to give insight into causes of mortality of children in order to identify and prioritize interventions to optimize patient care and quality of healthcare services in the paediatric emergency department. The review indicates that top causes of mortality remain virtually unchanged. Lastly, the study did not

investigate the skills and training of the staff providing care in the triage room and MEU, and pre-hospital setting. This may need further interrogation as poor skills may be a contributing factor particularly as much of the work of the unit occurred at time periods when there was less senior supervision.

### **Strengths**

This study captured and reported all the deaths that passed through the MEU for the period 2008. We identified all the causes of death, described the demographic characteristics of all the study children, their clinical presentation and treatment plans as well as speculated contributory and possible modifiable factors. Thereby we were able to compare with international literature and strengthen treatment protocols and management guidelines, as well as devise strategies to improve and address modifiable factors.

## Chapter Seven

### Conclusion

Significant gaps were identified in the pre-referral care of children with potentially life-threatening diseases. In particular, general practitioners did not provide emergency treatment. Dehydration and shock management represented a significant cause of death, the management of which was sub-optimal in some cases in 2008. In 2008, even the medical emergency unit management appeared sub-optimal at times. However, poor documentation may have been a contributing factor.

### Recommendations

We recommend that the MEU reviews the results of this study and considers conducting a modern prospective clinical study to critically review the current performance of this tertiary unit in providing quality emergency care to children to see if the problems raised have changed after modifications to protocols, training, duty rosters, staffing levels, patient flow and minimised delays, consultant presence after-hours, provision of dedicated trained coding staff and encouraging an ethos of research with the ultimate view to sustaining and maintaining best practice. Sharing this information at a wider forum may be of interest to provincial governance groups who may wish to critically review the pathways to care, management and outcomes for critically ill children from home to the definitive hospital bed and home again. Regular auditing as a quality improvement strategy would help identify remaining barriers inhibiting the achievements of the SDGs.

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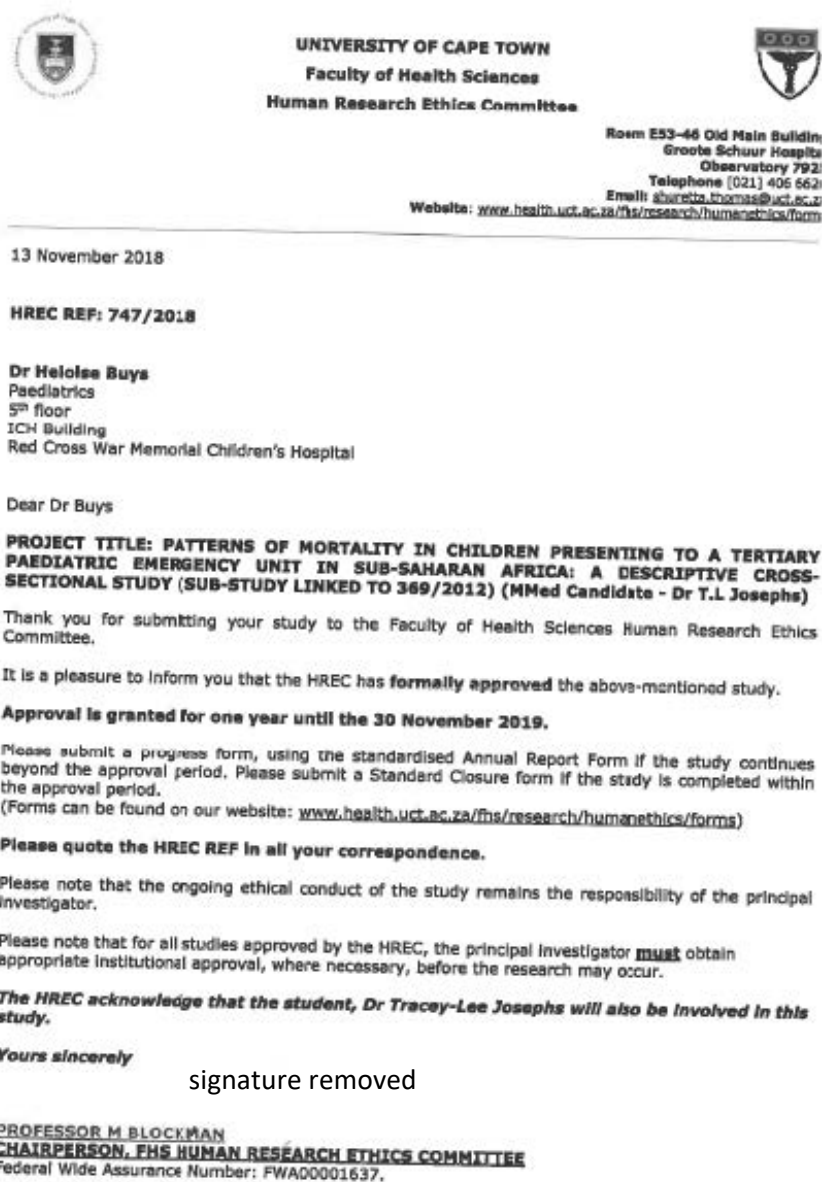
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## 975 Appendices

### 976 Appendix 1: Ethics approval letter



977

978 **Appendix 2: Protocol**  
 979  
 980 **Research Proposal**  
 981 **Patterns of mortality in children presenting to a tertiary paediatric emergency unit in Sub-Saharan**  
 982 **Africa: a cross sectional study**  
 983  
 984 Researchers:  
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 987  
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 994  
 995 Background  
 996 The Sustainable Development goals (SDGs) were adopted in 2015 at a United Nations congress and  
 997 address challenges faced globally with regards to poverty, inequality, prosperity, justice and various

998 other challenges. (1, 57) One of the SDGs is an aim to reduce child mortality to less than 25 per 1000 live  
999 births by the year 2030. Globally, the main killers of children under age 5 in 2016 were preterm birth  
1000 complications (18%), pneumonia (16%), intrapartum-related events (12%), diarrhoea (8%), neonatal  
1001 sepsis (7%) and malaria (5%). (4)

1002

1003 Prior to the SDGs, the Millennium Development goals (MDGs) were devised by the United Nations (UN)  
1004 in the year 2000. The MDG 4 stated that by the year 2015, the aim would be to reduce global mortality  
1005 by two thirds. (3) Globally, the under-five mortality rate (U5MR) has decreased from 93 per 1000 live  
1006 births in 1990 to 41 per 1000 live births in 2016, a 56% reduction in mortality. (4) However, while global  
1007 mortality has decreased, the World Health Organisation (WHO) reported that Africa still had the highest  
1008 incidence of under 5 mortality, 76.5 per 1000 live.

1009

1010 In order for Sub-Saharan Africa to achieve the SDG goal on child mortality progress needs to accelerate  
1011 to combat the top causes of mortality in the region. The top causes of mortality are pneumonia,  
1012 diarrhoea, malnutrition and malaria. Factors contributing to these causes of mortality are rural living,  
1013 poor access to resources, poverty, maternal age and parental education level. (58-60)

1014

1015 In South Africa, The Child Problem Identification Programme (Child PIP) is a system implemented to look  
1016 at trends in mortality, as well as identification of modifiable factors. Child PIP data is collected at all  
1017 government hospitals across the country and a report is collated with regards to childhood mortality.  
1018 (61, 62) The under-five mortality rate in South Africa declined from 59 in 2000 to 34.7 in 2015 but has

1019 subsequently remained stagnant. (30, 63). The top causes of mortality in South African children are  
 1020 prematurity-related, pneumonia, gastro-enteritis and injuries. (64, 65)

1021 Many children suffering from one of the top causes of mortality present to health facilities critically ill.  
 1022 Recognizing critically ill children is the first step in their management. (66) These children should be  
 1023 correctly identified by a triage tool at presentation, and appropriately resuscitated. The need for triage  
 1024 to prioritise and categorise acutely ill children arriving at any hospital is highlighted by the fact that  
 1025 many deaths occur within the first 24 hours of presentation to hospitals in developing countries. (31, 59)  
 1026 Appropriate triage is critical to ensuring the delivery of timely emergency care. (67, 68)

1027

1028 The Emergency Triage, Assessment and Treatment tool (ETAT) was developed in 2005 in Malawi and has  
 1029 been endorsed by the WHO as a paediatric triage tool across many countries, including Rwanda, Kenya  
 1030 and Malawi.(59, 69, 70) In South Africa, it was rolled out in Kwazulu Natal and in the Eastern Cape in  
 1031 2016(71). RCWMCH is a hospital in the Western Cape which provides secondary and tertiary level care  
 1032 to 1.5 million children <14years from all over the Western Cape, as well as quaternary care to patients  
 1033 from across the country. According to the computerised hospital information system (HIS) application,  
 1034 Clinicom®, the medical emergency unit sees approximately 30 000 children who present per annum. In  
 1035 2007 Red Cross War Memorial Children's Hospital (RCWMCH) introduced ETAT, as an adapted triage  
 1036 tool, with a view to understanding the processes involved in the initial management of these children  
 1037 with respect to triage, resuscitation, management after admission and cause of death.(34) In 2013, a  
 1038 collaborative process merged the clinical discriminators of ETAT with the physiological measurements  
 1039 and a Triage Early Warning Score of another existing triage tool SATS to enhance the safety and  
 1040 sensitivity of the final revised tool called the Paediatric South African Triage Scale (PSATS)(72).

1041

1042 There is little data in Sub Saharan Africa highlighting the effective use of a triage tool (in this case ETAT)  
1043 and the impact it has on child mortality especially in the first 24 hours. This study aims to address the  
1044 gap as part of a quality improvement initiative.

1045 **Aim:**

1046 To evaluate the impact of factors associated with in hospital death of children admitted via the Medical  
1047 Emergency Unit (MEU) at the Red Cross War Memorial Children's Hospital (RCWMCH).

1048

1049 **Objectives:**

1050 • To describe the in-hospital mortality rate (per 1000 admissions via MEU) of children admitted to  
1051 the hospital via the medical emergency unit (MEU)

1052 • To describe the demographic characteristics, clinical presentation, and treatment plans of the  
1053 demised children to the MEU

1054 • To describe the cause(s) of death

1055 • To describe factors leading to death within 24 hours of admission

1056 • To assess if timing of treatment impacts on mortality of children in the MEU

1057

1058 **Methods:**

1059 Study design

1060 Cross sectional study with an analytical component

1061 Sample size:



1062 The sample population will be the 136 children who died in 2008.

1063

1064 **Inclusion Criteria:**

1065 Children that died following treatment in the medical emergency service at RCWMCH within the study  
1066 period 2008.

1067 **Exclusion Criteria**

1068 • Children that died who were admitted to the Red Cross War Memorial Children's Hospital via  
1069 other areas e.g. Trauma Unit; directly into ICU from outside RCWMCH or surgical wards

1070 • Children transferred from other hospital wards other than casualty/emergency rooms.

1071 • All children who were 'Dead on Arrival' (DOA)

1072 Data collection:

1073 This is a secondary data analysis on a database compiled in 2008 at the MEU at the RCWMCH. The  
1074 variables collected include:

1075

1076 Demographic data:

1077 Age, gender, weight, nutritional status, HIV status

1078

1079 Clinical data:

1080 Clinical presentation, ETAT information, vital signs, clinical diagnosis, pre-hospital and in-hospital  
1081 treatment.

1082

1083 Time factors:

1084 Time of admission, time to initiation of treatment, time to ward transfer.

1085

1086 Mortality data:

1087 Cause(s) of death, time to death, time of death and place of death

1088

1089 Data Analysis:

1090 The analysis will be done using Stata13v11 and will constitute descriptive and analytical components.

1091

1092 Numerical data

1093 Summary descriptive statistics will be done on numerical data reporting either median and interquartile

1094 ranges of means with ranges as appropriate. Means/Median with interquartile ranges/ranges (IQR) of

1095 numerical data with either a paired t-test or a Wilcoxon ranksum test with 95% Confidence Intervals (CI)

1096 and p-values reported. A significance level of  $p < 0.05$  will be chosen.

1097

1098 Categorical data

1099 Categorical data will be presented as proportions and chi-squared test performed between categorical

1100 data to look for association. The 95% CI and the p-values will be reported. A significance level of  $p < 0.05$

1101 will be chosen.

1102

1103 **Ethical considerations:**

1104 Risk-Benefit Ratio

1105 The benefits of this study outweigh the risks.

1106 This study is a minimum risk study as the personal data of patients will not be included in the study and  
1107 there will be no direct contact with the participants.

1108 The results will benefit the future management of patients presenting to the RCWMCH Medical  
1109 Emergency Unit (MEU) by identifying the variables leading to mortality.

1110 Independent Review

1111 The research will be submitted for ethical review to the Human Research Ethics Committee (HREC) at  
1112 the University of Cape Town.

1113 **Informed Consent**

1114 In view of the retrospective nature of the study, the Ethics committee will be approached to provide a  
1115 waiver of individual consent. All information pertaining the patient's credentials are stored in a  
1116 password protected computer and any other relevant data will be protected by the principal  
1117 investigator to guarantee anonymity. The data sheets feature alphanumeric characters assigned to each  
1118 patient to safeguard anonymity. Should the study be published in any form, all identifying information of  
1119 the patients will be removed.

1120

1121 **Confidentiality:**

1122 Data will be stored in a locked office on a password protected computer, with only the principal  
1123 investigator having access to the data. Study numbers (but not names / folder numbers) will be entered  
1124 on an electronic database for anonymous analysis and reporting.

1125

## 1126 **Timetable**

1127

1128 October 2018 Protocol completion and ethics submission

1129 December 2018 - March 2019 Data analysis

1130 March-August 2019 Discussion and write up

1131 October 2019 Publication submission

1132

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1268

1269 **Appendix 3: Data collection sheet**

1270 Study title: Patterns of mortality in children presenting to a tertiary paediatric emergency unit

1271 in Sub-Saharan Africa: a cross sectional study

1272

1273 Biographical information

Study number				
Folder number				
Date of birth				
Gender	MALE		FEMALE	
Date of arrival				
Time of arrival (triage)				
Date of death				
Time of death				
Triage form Y/N	Yes		No	
Triage Colour: Red/Orange/Green/Nil	Red	Orange	Green	Nil
Chief presenting problem if not RED (taken from triage form where available)				
	Tiny tot (<2 months)			
	Temperature			
	Trauma/surgical			

	Severe palmar pallor (Hb<5)	
	Poisoning (overdose)	
	Pain (severe)	
	Respiratory distress	
	Restless/irritable	
	Referral (urgent)	
	Malnutrition (visible severe wasting)	
	Oedema	
	Burns	
	Some dehydration (1 of 3 signs)	
	Unable to drink/feed OR vomits everything	
	Tender swelling behind ear	
	Mouth ulcers (severe)	
	Measles(complicated)	
	Nil (No triage form)	
	Other-specify	
	Nil specified	
Chief presenting problem RED  (taken from triage form where available)	RED CATEGORY SYMPTOMS	

	Airway and Breathing	
	Circulation	
	Coma	
	Convulsions	
	Dehydration and Diarrhoea	
	Other	
	Taken to emergency room ( no paper triage or triage form not filled)	
Presenting illness diagnosis(ICD 10)		
Underlying diagnosis(specify)		
Other co-morbid illnesses(specify)	1.	
	2.	
	3.	
	4.	
<b>Clinical parameters on arrival:</b>		
Time into ER:	Time out of ER/died:	
Transfer to :	Ward:	
Temperature in °C(axillary)		

Weight (Kg):			
<b>Airway and Breathing:</b>			
- Spontaneous respiration	Y	N	
- Arrived intubated	Y	N	
- Has tracheostomy	Y	N	
- RR (tachypnoea for age)			
- Sats < 92% in RA (hypoxia)			
- Stridor	Y	N	
- Wheeze	Y	N	
- Arrival saturation (%)			
- Departure saturation			
- needs more than NPO <sub>2</sub> to keep sats>92%	Y	N	
<b>Circulation:</b>			
- Cardiac arrest	Y	N	
- Admission tachycardia for age	Y	N	
- Admission bradycardia for age	Y	N	
- HR on arrival			
- HR on departure			
- CFT >2s	Y	N	
- Weak/feeble pulses	Y	N	
- Cold/mottled hands and/or feet	Y	N	

<b>Level of Consciousness (AVPU):</b>			
- Alert (A)			
- Lethargic(V)			
- Altered LOC			
- Coma (P, U)			
- Pupils fixed and dilated			
- Pupils pinpoint			
<b>Convulsions:</b>			
- Currently	Y	N	
- Immediately postictal	Y	N	
<b>Confusion:</b>	Y	N	
Dehydration and diarrhoea	Y	N	
- Lethargy			
- Sunken fontanelle			
- Slow skin pinch			
<b>Laboratory results:</b>			
pH (<7.25)			
Base deficit (>5 mmol/l)			
Lactate (>3mmol/l)			

Blood glucose <3mmol/l					
Positive blood culture(72h)	Y	N			
Organism grown					
Meningitis on CSF	Y	N			
HIV status (anytime during admission)	Exposed		Pos	Neg	Unknown
<b>Treatment given at referral facility:(taken from referral letter)</b>					
Oxygen	Y	N			
Intubated	Y	N			
Plasma expander bolus	Y	N	Volume:		
CPR	Y	N			
Antibiotic	Y	N	Name:		
Blood glucose checked	Y	N			
Anticonvulsant	Y	N			
Other (specify)					
Child referred	Y	N			
Telephonic warning	Y			N	
Referred from where				N/A	
Transport used					



<b>Therapy/resuscitation events in ER</b> <b>(taken from case notes)</b>			
<b>Airway and Breathing</b>			
Arrived intubated but ETT dislodged	Y	N	
Intubated in emergency room	Y	N	N/A
Given oxygen	Y	N	
Sats monitored	Y	N	
Saturation on	Admission:		Discharge:
Given nebulised adrenaline	Y	N	N/A
Given nebulised bronchodilator	Y	N	N/A
NCPAP	Y	N	N/A
IPPV	Y	N	N/A
CXR done	Y	N	N/A
<b>Circulation</b>			
External cardiac compressions	Y	N	N/A
HR monitored	Y	N	
HR on	Admission		Discharge
BP monitored	Y	N	
BP on	Admission		Discharge
IV line in situ on arrival	Y	N	
IV line inserted ER	Y	N	

IO line on arrival	Y		N	
IO line inserted in ER	Y		N	
Fluid bolus given(20ml/kg)	0	<20ml/kg	20-30ml/kg	31-40ml/kg
Fluid bolus>60ml/kg	Y		N	
Inotropes started	Y	N		N/A
<b>Disability</b>				
Antibiotics given before arrival	Y		N	
Antibiotic given in MEU	Y		N	
Time antibiotics given(MEU)	Y		N	
Blood glucose done	Y		N	
Blood glucose <3 mmol/l	Y		N	
Other drugs: (Y/N)	Activated charcoal			
	Adrenaline			
	Anticonvulsants			
	Bronchodilators			
	IV steroids			
	Mannitol			
	Calcium			

	Oral KCL	
	Sodabic	
	Other-specify	

1275

1276

Cause of Death if known-ICD-10 (list compiled from CHIP Causes of death list v2.0 Appendix 2-Code Lists 2007)		
	Acute diarrhoea, hypovolaemic shock	
	Acute respiratory infection	
	Aspiration of gastric contents or foreign body	
	Asthma	
	Cardiomyopathy	
	Cirrhosis, portal hypertension, liver failure	
	Complex congenital heart problem	
	Drowning	
	Meningitis	
	Myocarditis	

	Paraffin inhalation	
	Poisoning	
	Septicaemia	
	Status epilepticus	
	Severe malnutrition	
	HIV related disease	
	Surgical (acute abdomen)	
	Tuberculosis	
	Other-specify	

1277